Report 11663
17 June 2000

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AEROJET

Integrated Advanced Microwave Sounding Unit-A (AMSU-A)

Engineering Test Report

METSAT AMSU-A1 S/N 109 Weight and Center of Gravity Measurements

[redacted]

Contract No. NAS 5-32314
CDRL 207

Submitted to:

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

Submitted by:

Aerojet
1100 West Hollyvale Street
Azusa, California 91702

Aerojet

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TO: A. Nieto

FROM: R. Bahng

SUBJECT: METSAT AMSU-A1 S/N 109 Weight and Center of Gravity Measurements.

COPIES TO: J. Christman, D. Ficker, J. Linn, P. Patel, R. Platt, D. Tran, Electronic File

REFERENCES:

1. IS-2617547, Unique Instrument Interface Specification for the Advanced Microwave Sounding Unit Module A1 (AMSU-A1), RCA Corporation Astro-Electronics.
2. POES Configuration Change Request, AMSU-A1 METSAT Instrument Weight Increase, CCR Number 8118, March 24, 1998.
3. S-480-79, Performance Assurance Requirements for the EOS/METSAT Integrated Programs, Goddard Space Flight Center.
4. S-480-80, Performance and Operation Specification for the EOS/METSAT Integrated Programs, Goddard Space Flight Center.
5. AE-26151/3C, Process Specification: Center of Gravity and Weight Test Procedure for the AMSU-A System, GenCorp Aerojet Azusa, May 7, 1999.
6. OC-459 Rev. 2, METSAT AMSU-A Weight and Center of Gravity Test Procedure, GenCorp Aerojet Azusa.
7. Shop Order No. 787926, Center of Gravity and Weight Test Procedure for METSAT AMSU-A1 S/N 109 (P/N 1331720-3-WGT), GenCorp Aerojet Azusa.
8. Drawing No. 1333964, AMSU-A1 Thermal Interface Control and Instrument Configuration Drawing, GenCorp Aerojet Azusa.

PURPOSE

This memorandum for the METSAT (Meteorological Satellites) AMSU-A1 (Advanced Microwave Sounding Unit-A1) Project reports the weight and center of gravity location measurements of the A1 module with serial number 109 (Aerojet part number 1331720-3). The measurements were performed in order to demonstrate compliance of the A1 module with the Unique Instrument Interface Specification (RCA IS-2617547) on mechanical interface. The weight and center of gravity measurements will also be used in the documentation of the mass properties of this A1 module. The results of the measurements and their effects on compliance with the Interface Specification will be discussed herein.

SUMMARY

The weight and center of gravity location of the METSAT AMSU-A1 module, with assembly serial number 109, were measured on July 14, 2000 at the GenCorp Aerojet Azusa environmental testing facility. The measurements were taken in accordance with Aerojet Process Specification AE-26151/3C and Facility Test Procedure OC-459 Rev. 2. The following measurements were obtained:

Unit under Test: METSAT AMSU-A1 S/N 109
Weight: 119.93 pounds
X_{A1}: 9.94 inches
Y_{A1}: 10.41 inches
Z_{A1}: -8.92 inches

The center of gravity location (X_{A1}, Y_{A1}, and Z_{A1}) is relative to the instrument coordinate axes shown in the AMSU-A1 Outline Drawing in the Interface Specification. The instrument coordinate system is also defined in the AMSU-A1 Thermal Interface Control and Interface Configuration Drawing, with Aerojet drawing number 1333964. The AMSU-A1 module under test was measured with test thermal blankets. Connector savers and GSE (ground support equipment) were removed from the module during the measurements. The weight and center of gravity includes the mounting hardware (screws and washers) used to secure the instrument to the handling plate.

The Interface Specification for the AMSU-A1 instrument weight states, "the total weight of the AMSU-A1 instrument shall not exceed 119.5 pounds." A waiver, in Reference 2, increases the maximum weight of METSAT AMSU-A1 unit to 123.0 pounds. The former requirement of 119.5 pounds was increased to 123.0 pounds because of production changes and a new DC/DC converter, which increased the projected instrument weight. The weight of the METSAT AMSU-A1 S/N 109 unit, measured to be 119.93 pounds, is in compliance with the Interface Specification on instrument weight (Reference 1, Paragraph 3.2.1.2) with the waiver (POES Configuration Change Request CCR 8118).

The Interface Specification for center of gravity of the AMSU-A1 instrument states, "the maximum distance from the instrument's mounting surface to the center of gravity for the AMSU-A1 module shall be less than 10.3 inches." The distance from the mounting surface to the center of gravity location (Z_{A1}) of the METSAT AMSU-A1 S/N 109 instrument, measured to be 8.92 inches, is in compliance with the Interface Specification on center of gravity (Reference 1, Paragraph 3.2.1.5).

DISCUSSION

The measurements of weight and center of gravity location of the METSAT AMSU-A1 S/N 109 module were performed in accordance with Process Specification AE-26151/3C, Test Facility Procedure OC-459 Rev. 2, and Shop Order 787926. An illustration of the test setup is shown in Figure 1. The test setup utilizes three load cells to measure the weight and center of gravity of the AMSU-A1 module. The permadur load positioner, shown in Figure 1, was not used in the test. An overhead crane supports the load cell, labeled "L1". Load cells "L2" and "L3" are supported by I-beams

mounted to the head expander of the Unholtz-Dickie shaker in the vertical position. The three load cells support a handling fixture, with part number T-1291019. The handling fixture is also shown in Figure 2. The eyebolt attachment locations L1, L2 and L3 are shown in Figure 2. Shackles, turnbuckles, lanyards, and eyebolts are used to attach the load cells to the handling fixture. Weight readouts, from the load cells, were obtained from signal conditioners/indicators connected to each load cell.

The calibration of each load cell was verified previously by hanging various weights on each load cell independently. Figure 3 shows plots of measured versus applied weight for each load cell. Applied weights of 5, 10, 15, 20, 25, 50, 75, 100, and 125 pounds were used to verify the load cell calibrations. The load cell readouts were recorded on TDS 1 (Test Data Sheet 1) in AE-26151/3C. The measured versus applied weight plots are shown in Figure 3. The deviation of the measured from the applied weight is also shown in each plot. The plots show that the measured weight agrees with the applied weight within 0.4%. The load cell calibration checks demonstrate that each load cell is capable of measuring weight, between 5 and 125 pounds, within 0.4% of the applied weight.

The test setup was proof load tested on July 12, 2000. The test setup was proof load tested with the handling fixture and 250 pounds of additional weight for at least 5 minutes. The successful proof load test showed that the test setup could support more than twice the weight of the AMSU-A1 module; the AMSU-A1 module weighs approximately 120 pounds. The proof load test data was recorded on TDS 2 in AE-26151/3C.

The instrumentation and test procedures were validated through measurements of the weight and center of gravity location of a "calibrated" mass with known mass properties. The location of the mass relative to the handling fixture is shown in Figure 2. The load cell readings were initially "zeroed out" with only the mounting hardware attached (excluding the handling fixture and mass). To measure the weight and center of gravity of the mass, load cell readings were obtained from the four configurations:

1) handling fixture only, horizontal (0°)
2) handling fixture only, tilted 10° about the Y-axis of the fixture
3) handling fixture and calibrated mass, horizontal (0°)
4) handling fixture and calibrated mass, tilted 10° about the Y-axis of the fixture

The load cell readings were recorded in TDS 3 in AE-26151/3C. The weight and center of gravity calculation formulas are given in the Enclosure. The load cell readings and weight and center of gravity results are shown in Table I. Comparisons of measured and expected weight and center of gravity location are shown in Table III. The measured weight of the calibrated mass, 96.89 pounds, is within 0.13% of the known value of 96.764 pounds. The measured center of gravity location of the calibrated mass is within 0.3 inch of the known center of gravity location.

The METSAT AMSU-A1 S/N 109 instrument was side-mounted on the handling fixture. The outline of the module on the handling fixture is shown in Figure 2. The instrument was handled in accordance with Aerojet Handling Procedure AE-26357. Cleanliness control, according to AE-26495, and electrostatic control, according to MPI-09-008, were observed. The weight and center of gravity of the

module was measured with the same procedures as used for the calibrated mass. The test data was recorded on TDS 4 of AE-26151/3C. The load cells readings, and weight and center of gravity location results are shown in Tables II and III. The weight of the METSAT AMSU-A1 module, with serial number 109, was measured to be 119.93 pounds. The center of gravity location of the A1 unit under test was measured to be 9.94, 10.41, and –8.92 inches in the X_{A1}, Y_{A1}, and Z_{A1} coordinate axes, respectively. For comparative purposes, the measured weights and center of gravity locations of previously tested AMSU-A1 modules are shown with the mass properties of METSAT AMSU-A1 S/N 109 in Table IV. The variations in the weights of the KLM units are within 0.3 pound, while the KLM variation in center of gravity location are within an inch. The variations in the weights of the METSAT units are within 1.7 pounds, while the METSAT variations in center of gravity locations are within 0.3 inch. The apparently higher weight of the S/N 109 METSAT AMSU-A1 unit, than the rest of the METSAT AMSU-A1 units, is attributed to a different PLO (Phase Locked Oscillator). The TRW PLO, which replaced the original PLO, differs from those in the baseline METSAT units in that it has a large heatsink that may contribute to the overall higher weight (by about 1 pound) of the S/N 109 instrument. The average and standard deviation of the mass properties of the KLM, METSAT, and KLM/METSAT units, are also shown in Table IV.

The Interface Specification for the AMSU-A1 instrument weight states, "the total weight of the AMSU-A1 instrument shall not exceed 119.5 pounds." A waiver was received for the METSAT AMSU-A1 unit to not exceed 123.0 pounds. The weight of the METSAT AMSU-A1 S/N 109 unit, measured to be 119.93 pounds, is in compliance with the Interface Specification on instrument weight (Reference 1, Paragraph 3.2.1.2). The Interface Specification for center of gravity of the AMSU-A1 instrument states, "the maximum distance from the instrument's mounting surface to the center of gravity for the AMSU-A1 module shall be less than 10.3 inches." The distance from the mounting surface to the center of gravity location of the AMSU-A1 S/N 109 instrument, measured to be 8.92 inches, is also in compliance with the Interface Specification on center of gravity (Reference 1, Paragraph 3.2.1.5).

CONCLUSIONS/RECOMMENDATIONS

The measured weight and center of gravity location of the METSAT AMSU-A1 S/N 109 module are in compliance with the Interface Specification of mechanical interface. The agreement of the measured weight and center of gravity location of a calibrated mass with the expected values shows that the test instrumentation and procedures are suitable for measuring the mass properties of the A1 module.

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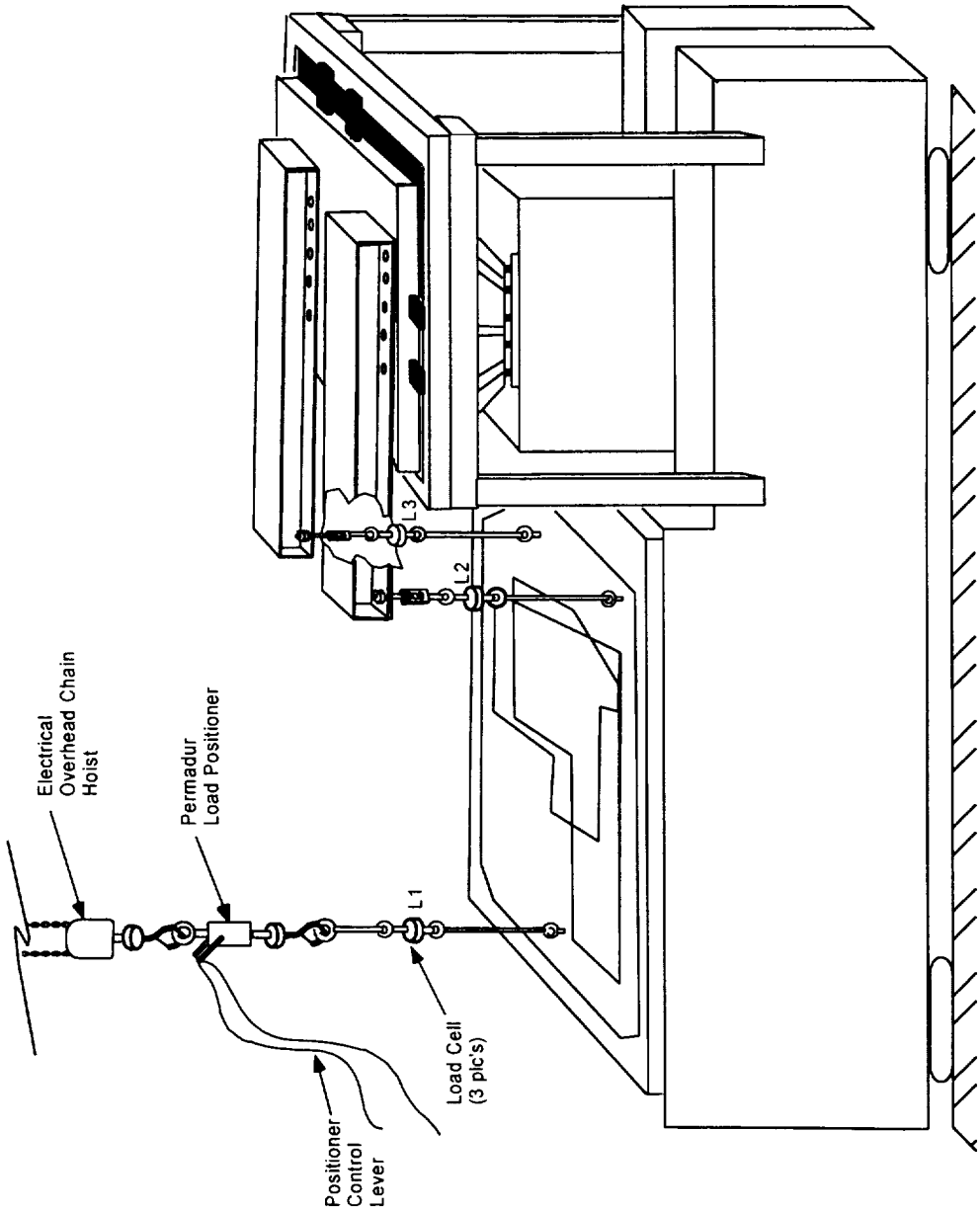

Figure 1. Weight and Center of Gravity Measurement Test Setup.

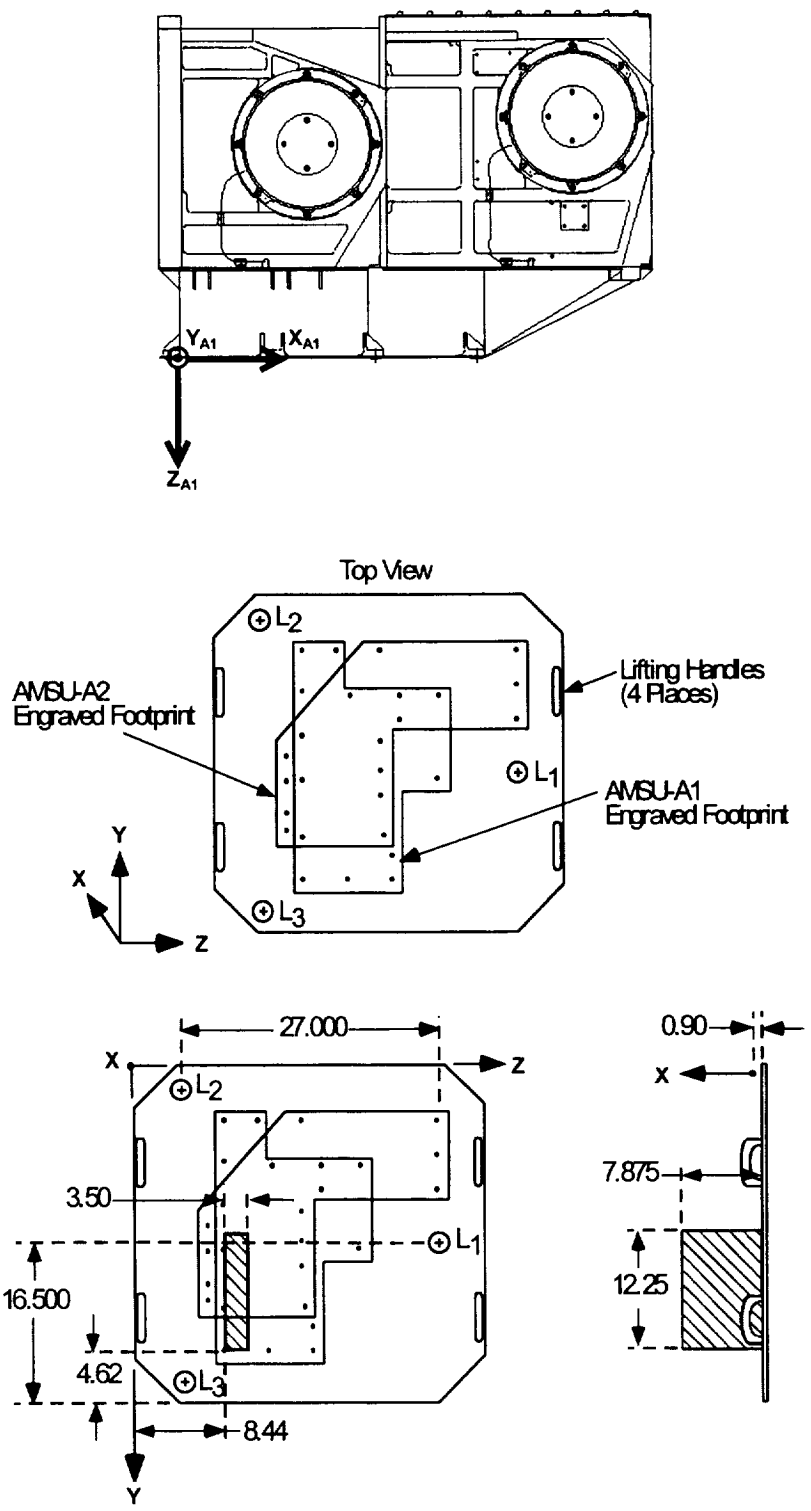

Figure 2. METSAT AMSU-A1 Coordinate Axes (above), Handling Fixture, 36x33x0.75 inches (center), and Calibrated Mass Location (below).

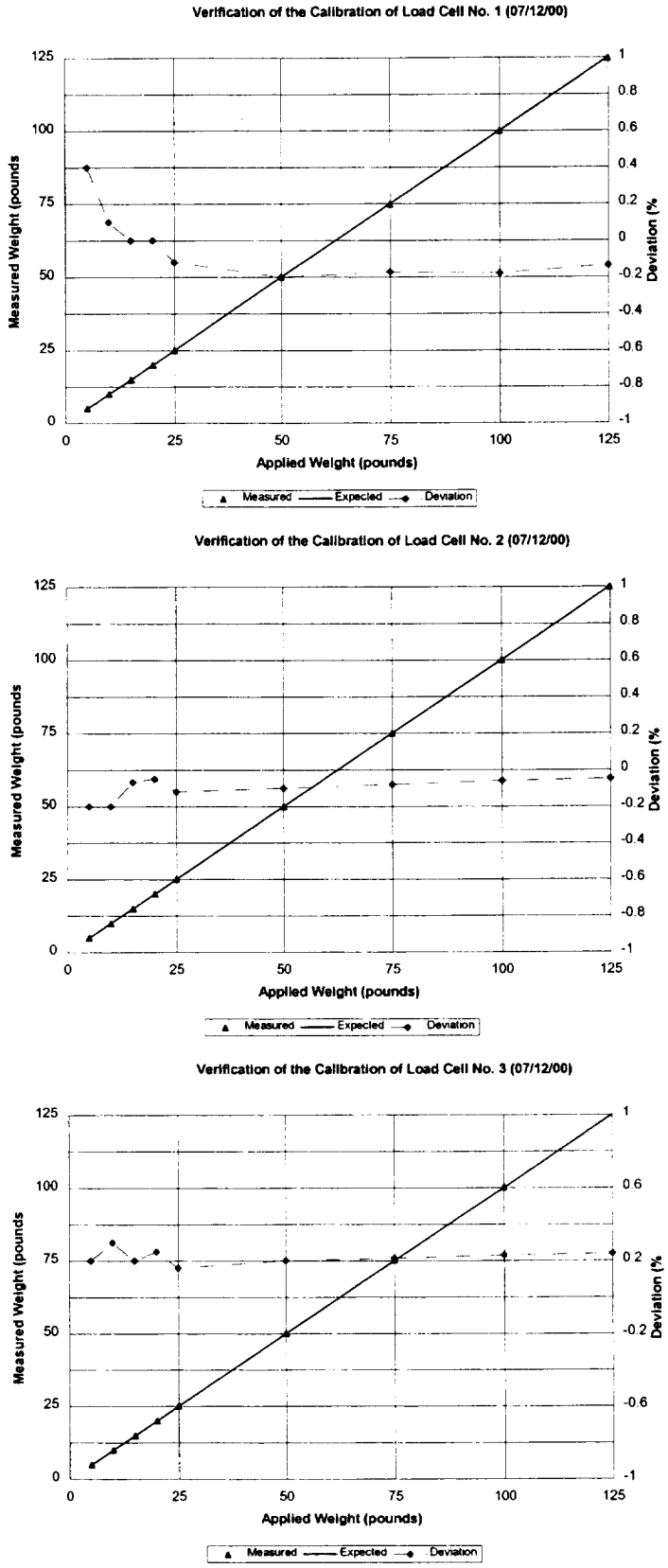

Figure 3. Pretest Load Cell Calibration Checks.

Table I. Calibrated Mass - Weight and CG Calculations

Geometry Point				Load Cell Reading			
Location Of Load Cell	a (in)	b (in)	c (in)	ABC (lbs)	DEF (lbs)	GHI (lbs)	JKL (lbs)
L1	1.15	16.50	31.50	44.49	64.76	45.06	63.34
L2	1.15	2.00	4.50	22.52	41.53	22.20	42.20
L3	1.15	31.00	4.50	22.32	79.93	22.03	80.76
Angle (degree)	10.00		SUM	89.33	186.22	89.29	186.30

Plate's Coord.	Plate (in)	Plate's Coord.	Mass (in)	A1's Coord.	Mass (in)	A2's Coord.	Mass (in)
X2	-0.97	**X1**	3.11	**XA1**	2.21	**XA2**	4.26
Y2	16.47	**Y1**	22.28	**YA1**	19.33	**YA2**	-18.88
Z2	17.95	**Z1**	10.15	**ZA1**	-4.26	**ZA2**	22.15
Weight (lbs)	89.33		96.89				

Table II. METSAT AMSU-A1 S/N 109 Unit - Weight and CG Calculations

Geometry Point				Load Cell Reading			
Location Of Load Cell	a (in)	b (in)	c (in)	ABC (lbs)	DEF (lbs)	GHI (lbs)	JKL (lbs)
L1	1.15	16.50	31.50	44.49	103.92	45.06	98.38
L2	1.15	2.00	4.50	22.52	65.77	22.20	68.50
L3	1.15	31.00	4.50	22.32	39.57	22.03	42.47
Angle (degree)	10.00		SUM	89.33	209.26	89.29	209.35

Plate's Coord.	Plate (in)	Plate's Coord.	Unit (in)	A1's Coord.	Unit (in)	A2's Coord.	Unit (in)
X2	-0.97	**X1**	7.77	**XA1**	9.94	**XA2**	8.92
Y2	16.47	**Y1**	13.36	**YA1**	10.41	**YA2**	-9.96
Z2	17.95	**Z1**	17.88	**ZA1**	-8.92	**ZA2**	14.42
Weight (lbs)	89.33		119.93				

Table III. Weight and CG Summaries

CG Summary	Axis	Plate Coord. (in.) Measured	Plate Coord. (in.) Expected	Metsat A1 Coord. (in) Measured	Metsat A1 Coord. (in) Expected	Discrepencies Difference	Discrepencies % Diff.
Calibrated Mass	X	3.11	2.81	2.21	2.25	-0.04	-1.84
	Y	22.28	22.25	19.33	19.31	0.03	0.14
	Z	10.15	10.19	-4.26	-3.96	-0.30	7.56
METSAT AMSU-A1 S/N 109	X	7.77		9.94			
	Y	13.36		10.41			
	Z	17.88		-8.92			

Weight Summary	Weight (lbs) Measured	Weight (lbs) Expected	Discrepencies Difference	Discrepencies % Diff.
Calibrated Mass	96.89	96.76	0.13	0.13
METSAT AMSU-A1 S/N 109	119.93			

Table IV. Database of AMSU-A1 Weight and (C. G.) Center of Gravity Measurements

Spacecraft; Sensor S/N	Aerojet Ref. Memorandum	Weight (lbs)	C. G. X_{A1} (inches)	C. G. Y_{A1} (inches)	C. G. Z_{A1} (inches)
KLM 102	95/08 #660	117.15	10.02	10.62	-8.97
KLM 103	94/17	117.2	10.06	10.64	-9.99
KLM 104	95/09	117.5	10.03	10.61	-9.01
METSAT 105	1999#159	119.0	9.92	10.43	-9.05
METSAT 106	1999#297	118.2	9.95	10.39	-9.21
METSAT 107	1999#515	118.5	9.91	10.41	-9.26
METSAT 108	2000#311	118.89	9.95	10.41	-9.18
METSAT 109	***2000#583***	***119.93***	***9.94***	***10.41***	***-8.92***

Statistics	Weight (lb) Avg. ± Std. Dev.	C. G. X_{A1} (inches) Avg. ± Std. Dev.	C. G. Y_{A1} (inches) Avg. ± Std. Dev.	C. G. Z_{A1} (inches) Avg. ± Std. Dev.
KLM	117.28 ± 0.19	10.04 ± 0.02	10.62 ± 0.02	-9.32 ± 0.58
METSAT	***118.90 ± 0.66***	***9.93 ± 0.02***	***10.41 ± 0.01***	***-9.12 ± 0.14***
KLM and METSAT	118.30 ± 0.98	9.97 ± 0.06	10.49 ± 0.11	-9.20 ± 0.34

ENCLOSURE:

Formulas for AMSU-A1 and A2 Weight and Center of Gravity Calculations

a. Location of load cell attachment points (in inches):

(1) a_1, a_2, a_3: location of eyebolts/load cells, measure from the plate to the contact point between the eyebolt and the anchor shackle.
(2) $b_1 = 16.50$; $b_2 = 2.00$; $b_3 = 31.00$: Y location of eyebolts/load cells, in plate coordinate system.
(3) $c_1 = 31.50$; $c_2 = 4.50$; $c_3 = 4.50$: Z location of eyebolts/load cells, in plate coordinate system.
(4) $\alpha = 10.0°$ (tilted angle measured from horizontal position)
(5) $a = (a_1+a_2+a_3) / 3$

b. Load cell readings (L_1, L_2, L_3) (in pounds):

(1) A, B, C: plate only, horizontal position (0 degree)
(2) D, E, F: plate and AMSU unit, horizontal position (0 degree)
(3) G, H, I: plate only, tilted to 10 degrees from horizontal.
(4) J, K, L: plate and AMSU unit, tilted to 10 degrees from horizontal.

c. AMSU Weight (in pounds):

(1) Weight = D + E + F - A - B - C

d. AMSU center of gravity in plate coordinate system (in inches):

(1) $X_1 = [(D-A + G-J) c_1 + (E-B + H-K) c_2 + (F-C + I-L) c_3] / (J+K+L-G-H-I) / \tan(\alpha)$
(2) $Y_1 = [(D-A) b_1 + (E-B) b_2 + (F-C) b_3] / (D+E+F-A-B-C)$
(3) $Z_1 = [(D-A) c_1 + (E-B) c_2 + (F-C) c_3] / (D+E+F-A-B-C)$

e. Transformation to A2 coordinate system (in inches):

(1) $X_{A2} = a + X_1$
(2) $Y_{A2} = 3.40 - Y_1$
(3) $Z_{A2} = 32.30 - Z_1$

f. Transformation to A1 coordinate system (in inches):

(1) $X_{A1} = Z_1 - 7.940$
(2) $Y_{A1} = Y_1 - 2.943$
(3) $Z_{A1} = -X_1 - a$

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Report Documentation Page

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16. ABSTRACT (*Maximum 200 words*)

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13. ABSTRACT (*Maximum 200 words*)

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DOCUMENT APPROVAL SHEET

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Engineering Test Report METSAT AMSU-A1 S/N 109 Weight and Center of Gravity Measurements	Report 11663 17 June 2000

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Product Team Leader (A. Nieto)	8410	7/28/00
Systems Engineer (R. Platt) P. R. Patel	8410	7/28/00
Design Assurance (E. Lorenz)	8410	7/29/00
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